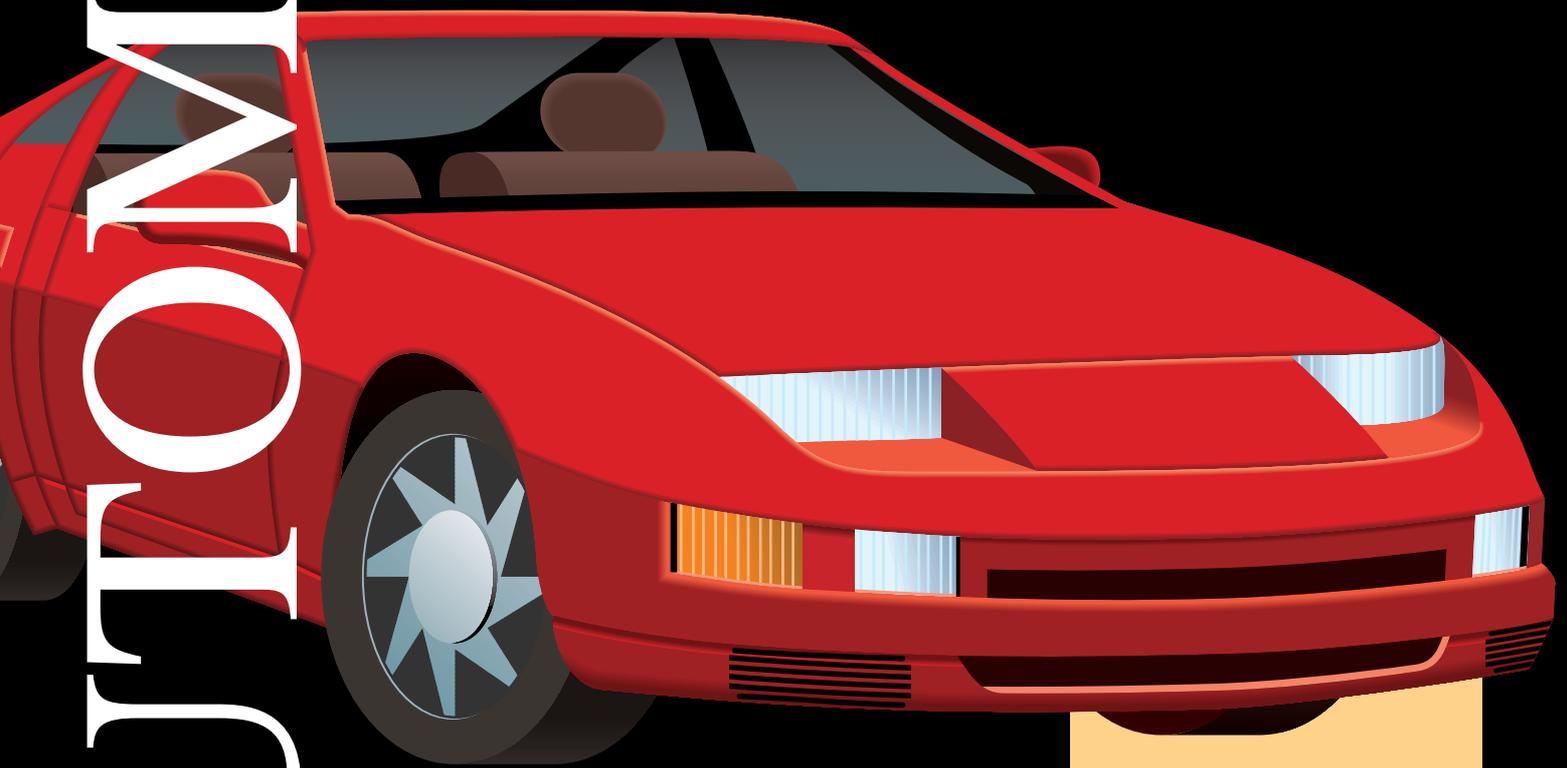


# AUTOMOTIVE VESPEL®



Vespel®  
Only by DuPont

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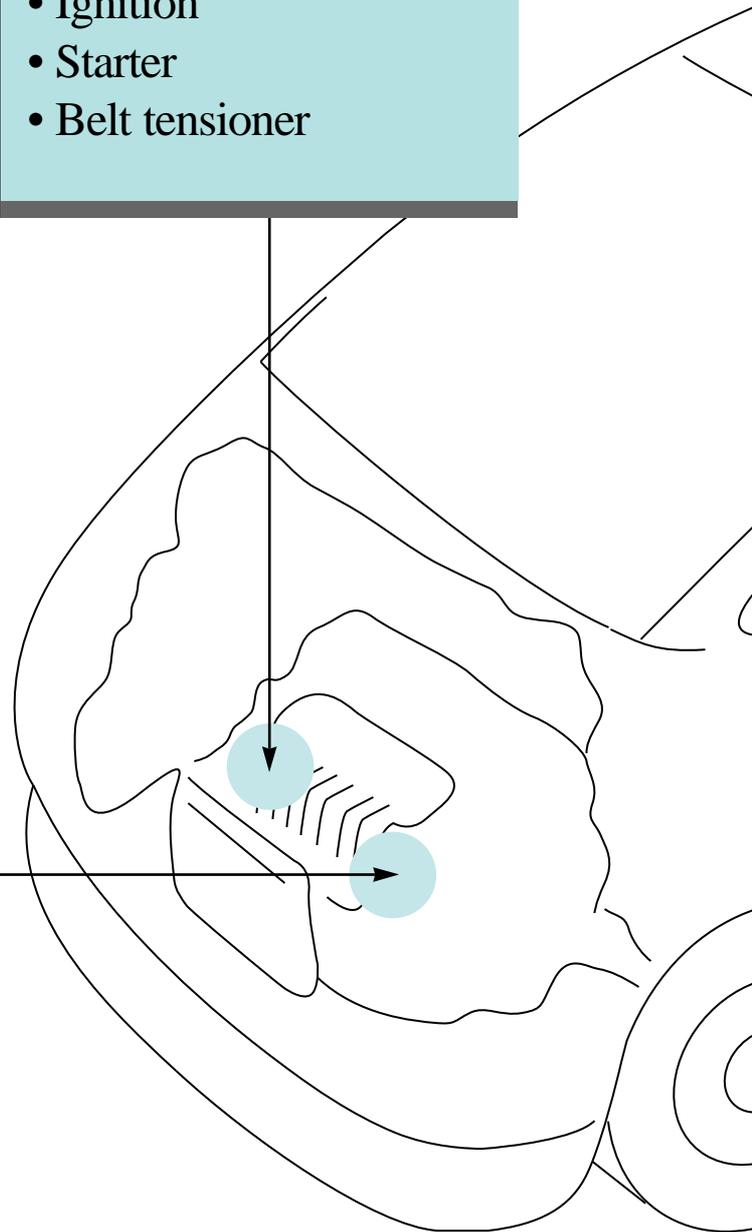
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## Under bonnet

- Fuel systems
- Turbocharger
- EGR
- Vacuum pumps
- Ignition
- Starter
- Belt tensioner

## Transmissions

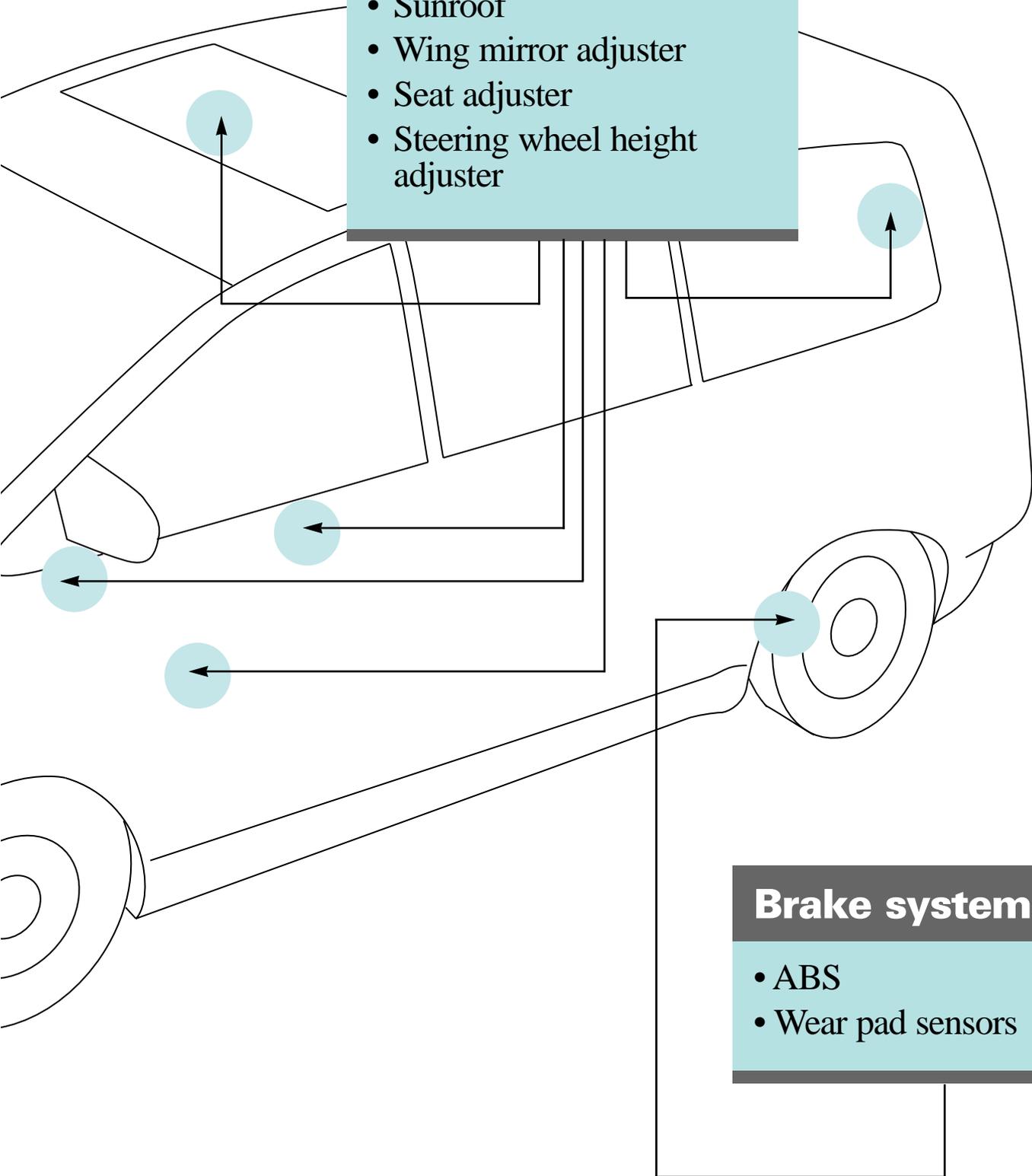
- Automatic gear boxes
- Clutches



# VESPEL®

## Electrical motors

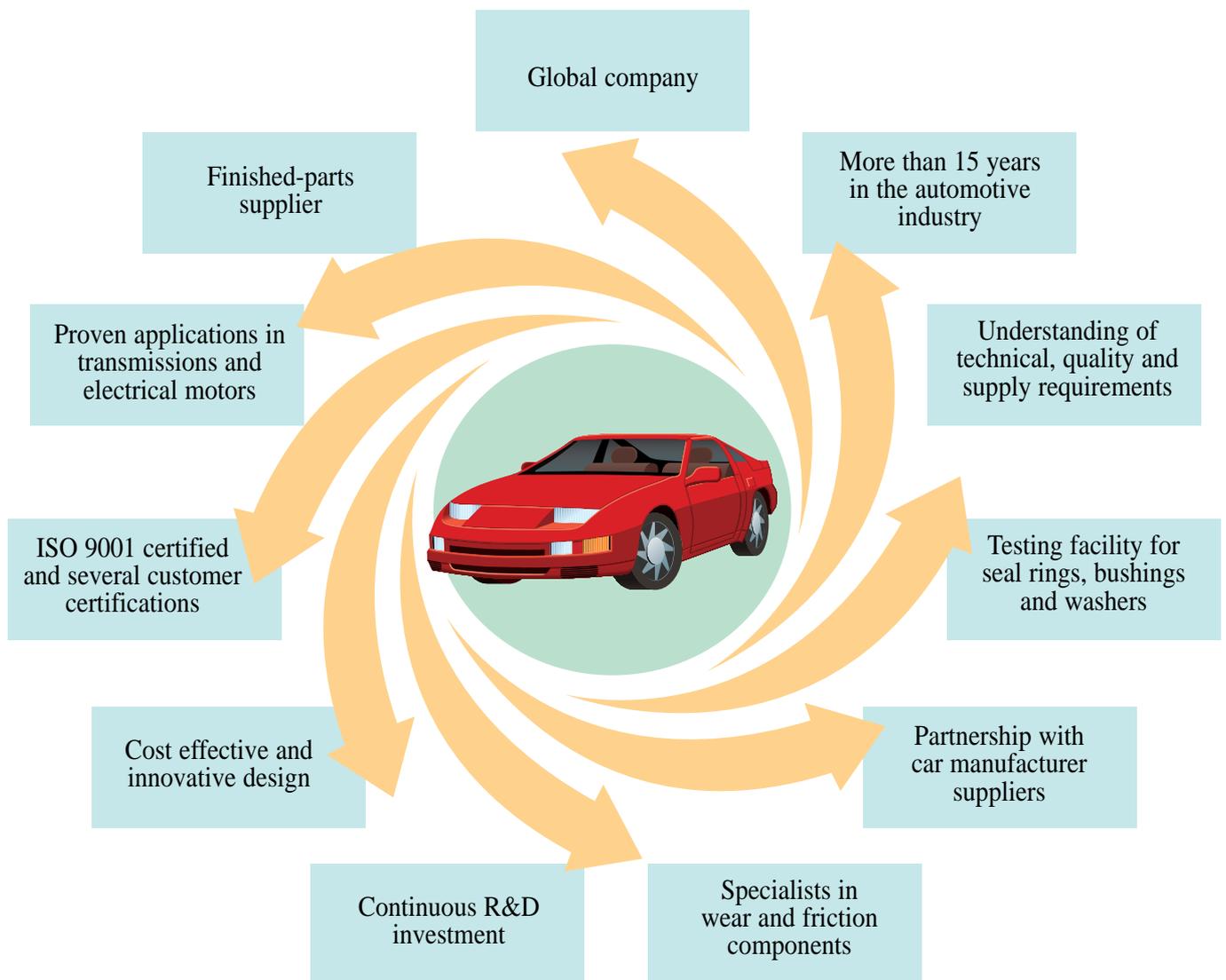
- Window lift
- Windscreen wiper
- Sunroof
- Wing mirror adjuster
- Seat adjuster
- Steering wheel height adjuster



## Brake systems

- ABS
- Wear pad sensors

# VESPEL® PARTS AND SHAPES



# VESPEL®

# PROPERTIES...

## Excellent compressive properties

- High elastic limit
- Non brittle
- High deformation capability

## Temperature resistance

- No melting point
- No T<sub>g</sub>
- Continuous use 290°C, excursions to 480°C

## Insulation

- Thermal
- Electric

## Polymer

- Light weight
- Dampens vibration

## Wear and friction problem solver

- Low CF
- Low wear rate
- Constant CF



## Impact resistance

## Machinability

- Similar to brass
- Quality 7 tolerances achievable

## High PV capability with or without lubrication

- PV value (dry) = 12 MPa m/s
- PV value (lubricated) = 40 MPa m/s
- Instantaneous PV limit (lubricated) = 140 MPa m/s

## Chemical compatibility

- With oil
- With solvents
- With fuels (diesel/gasoline)

## Electrical insulation

- Parts retain their good electrical properties at high temperatures

# PROPERTIES...

- Easy assembly
- No breakage
- Sealing compliance

- Excellent compressive properties**
- High elastic limit
- Non brittle
- High deformation capability

- Can protect other components

- Thermal insulation**
- Can protect other components

- Longer life
- Reliability
- Reduced power consumption
- Reduced warranty costs

- Wear and friction problem solver**
- Low CF
- Low wear rate
- Constant CF

- Fast prototyping
- Complex geometries and tight tolerances achievable with secondary machining

- Machinability**
- Similar to brass
- Quality 7 tolerances achievable

- No corrosion
- Works successfully in contact with all automotive chemicals

- Chemical compatibility**
- With oil
- With solvents
- With fuels (diesel/gasoline)

# ... INTO BENEFITS

- Works successfully in the hottest areas of the engine
- Withstands all car assembly processes
- Can be overmoulded
- Safety

- Temperature resistance**
- No melting point
- No T<sub>g</sub>
- Continuous use 290°C, excursions to 480°C

- Polymer**
- Light weight
- Dampens vibration

- Weight reduction
- Low inertia for movable components
- Noise reduction

- Impact resistance**

- Suitable for high frequency vibration
- Resists impact

- High PV capability with or without lubrication**

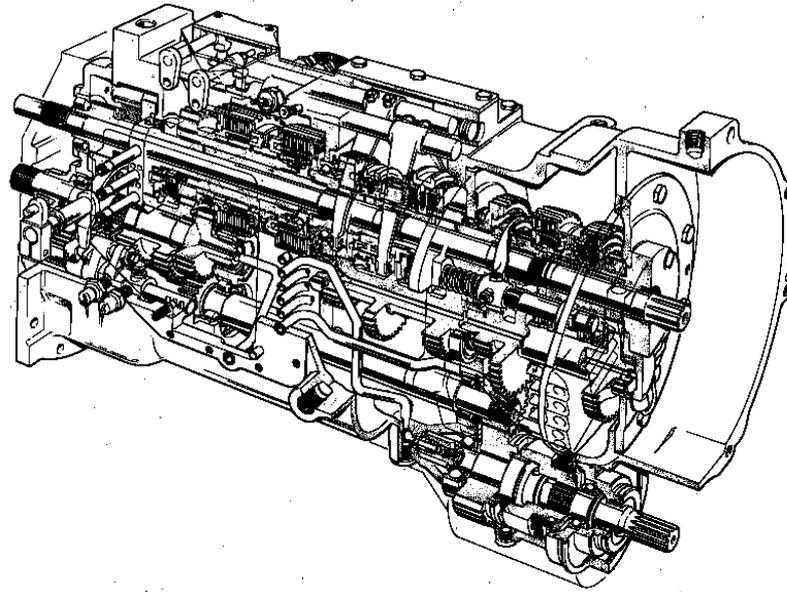
- PV value (dry) = 12 MPa m/s
- PV value (lubricated) = 40 MPa m/s
- Instantaneous PV limit (lubricated) = 140 MPa m/s

- Can run without lubrication
- Reduction of contact area, i.e. part size
- Increased safety margin in case of misuse
- Parts will run dry should lubrication fail
- Lower warranty costs

- Electrical insulation**

- Parts retain their good electrical properties at high temperatures





In the last few decades, automatic gearboxes and transmissions have increasingly replaced manual devices in cars, trucks, tractors and off-road vehicles.

Driving comfort, optimization of engine torque output, fuel saving and new pollution regulations have now become the driving force in the automotive industry.

The design of hydraulic units is complex as it has to take into consideration such aspects as: leakage control, sealing, vibrations, high loads & speeds, high temperatures generated by friction, durability and reliability. In certain extreme conditions mechanical components, normally lubricated by the surrounding oil, may have to run dry, generating excess heat and leading to failure.

The introduction of Vespel® as wear and friction components such as ***Thrust Washers, Seal Rings and Valve Seats***, has increased both performance and lifetime. At the same time overall costs can be reduced by:

- easier assembly of seal rings
- elimination of forced lubrication
- elimination of heat treatment on mating material
- wider tolerances on machined mating surfaces

## Thrust washers

With its very high PV limit of 12 MPa.m/s in dry conditions coupled with good compressive properties, Vespel® has been successful in applications such as thrust washers in hydraulic transmissions and also in split flywheels (clutches) coupled with manual gearboxes. Vespel® washers (with outside diameters of up to 90 mm) have proved their superior performance in tractor, truck and car transmissions by working in a normal oil mist environment and reaching PVs of up to 40 MPa.m/s and speeds of 7000 rpm. They can even accept instantaneous PVs of 140 MPa.m/s during gear changes in a forced lubrication environment.

The flexibility of Vespel® means that when the loading and speed conditions are known the design can optimize contact area (outside and inside diameters). Features can also be added to centre the part or to prevent rotation in order to select the sliding surface.

# VESPEL®

Radial grooves, which can be manufactured without additional machining, facilitate lubrication and therefore increase PV limit. Vespel® thrust washers resist static load without creep and impacts, and avoid the seizing often seen with metal/metal solutions.

## Seal rings

Vespel® seal rings operating inside the transmission work dynamically, mainly in the radial direction but also sometimes in an axial linear direction. Their function is to provide a seal between the shaft and the housing at given pressures and speeds so that clutches, i.e. gears, can be actuated.

A small leakage is nevertheless required here in order to lubricate other components such as needle bearings and gears, and also to avoid high surface temperatures. Lifetime and reliability are very important as they both influence the shifting operations.

Vespel® seal rings are designed according to customers requirements of speed, pressure, temperature, desired leakage rate, mating material and allowable wear.

Some of today's existing and proven Vespel® applications are:

- Tractor transmissions at speeds of about 2,500/3,000 rpm diameters up to 80 mm and pressures of 12 bars.
- Passenger car automatic gearboxes at speeds of 7,000 rpm for diameters up to 52mm and pressures of 12 bars.
- Automotive continuous velocity transmissions (CVT) at speeds up to 10,000 rpm for diameters about 20mm and pressure of 20 bars.

Seal ring gap type and dimensions are calculated to provide appropriate leakage at the given temperatures and pressures. Wear can be minimized by optimizing the contact area. With their outstanding chemical and creep resis-

## Valve seats

The reduction and control of oil leakage within the transmission is an important issue. The sealing compliance and resilience properties of



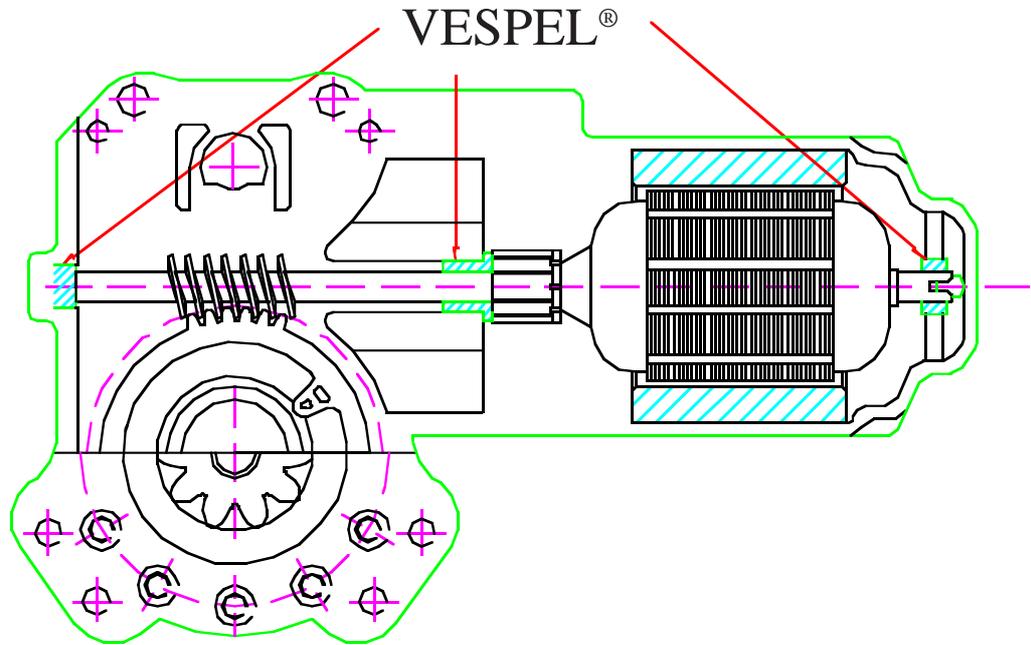
tance, Vespel® seal rings are neither attacked by hot oil nor extruded between shaft and housing due to pressure and heat.

Compared to other materials the assembly of Vespel® seal rings is easy and can be automated. The inherent flexibility of Vespel® makes seal rings easy to open without breakage while its toughness avoids deformation when inserting on the shaft.

With hydraulic pressure, seal rings will then conform to the housing, without creeping, to provide sealing.

Vespel® make it the ideal material for valve seats. They can be easily press-fitted into the housing and can eliminate the need for an "O" ring. Operating successfully in pressures of 20 MPa, Vespel® valve seats have demonstrated a high level of resistance to the abrasive action of metal particles in dirty hydraulic oil while providing a reliable sealing performance over time while resisting impact.

# ELECTRICAL MOTORS



The search for comfort and safety in the automotive industry has led to increased numbers of electric motors.

These are now widely used to make driving more pleasant (window lift, sunroof, central locking, air conditioning actuation, seat, mirrors & steering adjustment) and safer (windscreen wipers, idle and exhaust controls, differential locking).

Increasing regulations and specifications for equipment such as starter-motors and fuel pumps place greater demands on mechanical wear and friction components.

Parts such as *bushings*, *washers* and *thrust plugs* working in electrical motors have to withstand axial and radial loads coupled with speed.

The wear and friction characteristics of VespeL® have helped electrical motor manufacturers to simplify their design while improving performance and life.

# VESPEL®

## Bushings

Used in all kinds of electrical motors, Vespel® bushings can run with or without lubrication depending on the application. A "straight" bushing design is adapted to radial loading but a "flanged" design can additionally bear axial loads and therefore eliminate the need for a washer.

Parts can easily be press-fitted into the housing while maintaining very good control of the inside diameter. In addition, the high PV capability enables the length of the bushing to be reduced.

In these types of application, a low and constant coefficient of friction is required as well as wear and creep resistance.

The various Vespel® graphite filled grades provide cost effective solutions.

## Washers

Washers take the axial load in electrical motors which means that while providing wear and friction resistance as bushings do, they also have to withstand impact.

Due to the small loading area of such components, both pressure and velocity conditions can be high, generating excessive frictional heat.

The creep resistance and the PV capability of Vespel® washers guarantee long and reliable life of the equipment.

Noise, often generated by metallic parts running against each other, is eliminated.

## Thrust plugs

Specifically used in windscreen wipers, window lift, sunroof, seat adjusting, differential lock motors, etc., thrust

plugs are parts that are directly fitted into the rotor shaft with a slight interference.

Like washers, these parts have to take axial loads, and resist creep and wear.

Depending on the application, a low or relatively high coefficient of friction may be required, and unfilled SP 1 or SP 21 filled with graphite are the usual preferred choices.

During very severe use, Vespel® thrust plugs will not melt and therefore guarantee the function.



# BRAKES



Braking is the most important function in a vehicle today and the main emphasis is on safety.

Anti-lock braking systems regulate the brake fluid pressure applied at each wheel to avoid skidding and optimize braking.

Wear pads are equipped with electrical sensors that detect when the lining material is worn and alert drivers via a light on the dashboard.

The properties of VespeL® enable it to resolve the technical problems in both areas.

## Anti-lock braking systems

Used as valve components, (seats, balls) VespeL® parts provide excellent sealing due to their outstanding compressive behaviour. They also resist high impact and improve response time with their light weight.

## Wear pads

VespeL® sensors are installed into the metallic support of brake pads. The sensor insulates, both thermally and electrically, the wire which connects to a brake wear warning light.

Here the material has to provide a low and constant wear rate, without melting; and without depositing any film on the disc that would damage it by modifying the electrical contact.



# VEspeL®

# FUEL SYSTEMS



Gasoline and diesel injection systems require supply and injection pumps. Depending on fuel type and function, they have different working pressures and designs, but all need wear and friction and/or sealing components that can guarantee life and performance.

Vespel® has excellent chemical compatibility with various types of fuels without excessive swelling, which ensures the success of Vespel® parts such as *bushings, seal rings, band springs and valve seats*.

# TURBO CHARGERS

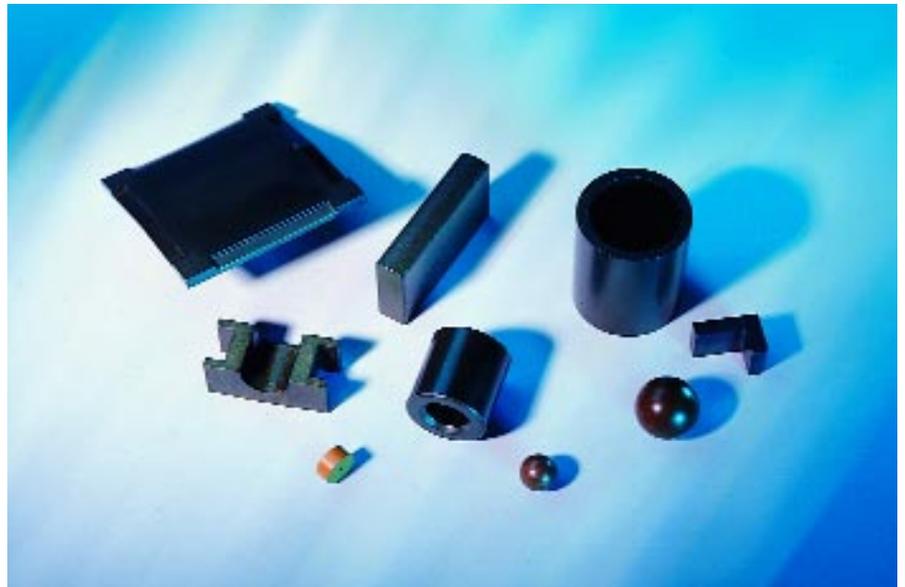
Turbo chargers are characterized by very high running speeds and high temperatures. Turbo chargers are devices where Vespel® can demonstrate its properties.

As *ball bearing retainers*, Vespel® can improve response time of the turbocharger through low weight and inertia.

As *wastegate bushings*, Vespel® can provide the required sealing without wear and abrasion of the shaft.

Similar benefits under these conditions have been proven in *Exhaust Gas Return (EGR) systems*.





VespeL® parts have a unique combination of properties which has enabled them to be used in a wide variety of automotive applications.

For example:

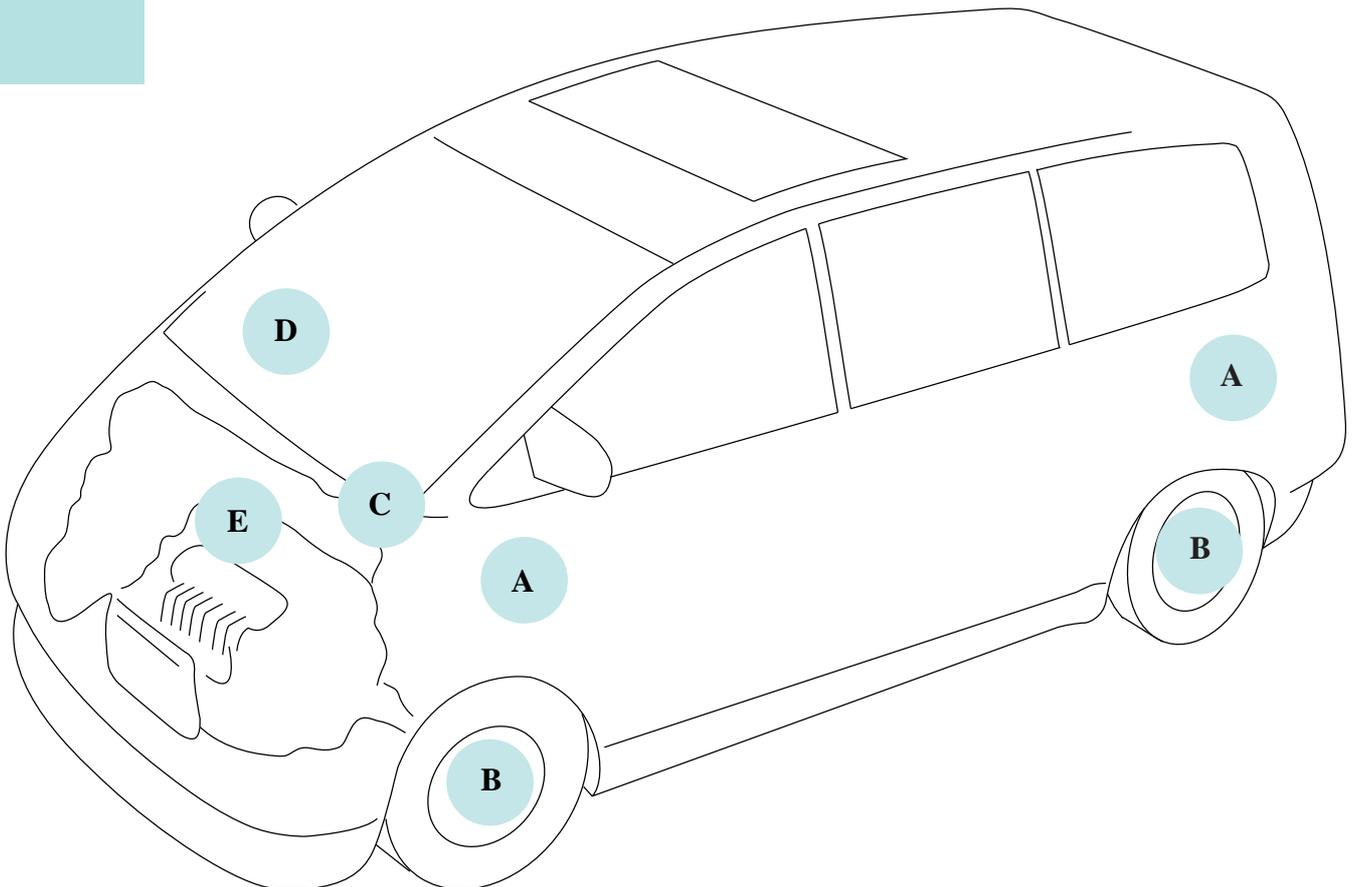
- ***Vacuum pump vanes*** where outstanding wear behaviour guarantees sealing without abrasion of housings, often in soft metal
- ***Engine belt tensioners*** which provide wear and friction characteristics while eliminating mating material wear debris.
- ***Rubbing blocks*** in ignition distributors to actuate breaker points, which guarantee constant wear rate and resistance to vibrations at high temperature.
- ***Door hinge bushings*** which survive paint oven temperatures and cleaning fluids while providing reliability of operation if there is any loss of lubricant.
- ***Gear stick rollers*** for automatic and manual transmissions which have low wear during intensive use conditions.

# VE SPEL®

# OPPORTUNITIES

Besides all applications described previously, many other opportunities can be seen for Vespel® in areas such as:

- **Wheel disc nuts (B)**
- **Steering systems (C)**
- **Air conditioning (D)**
- **Suspension systems (A)**
- **High temperature engine applications (E)**
- **Intake and exhaust systems (E)**
- **Piston rings (E)**
- **Shock absorbers (A)**



## Summary of typical properties of Vespel® SP polyimide resins

Properties	Temp. °C	Method ASTM	Unit	SP1	SP21	SP22	SP211	SP221 *	SP262 *
Tensile strength, ultimate	23 260	D 1708	MPa	72.4 36.5	62 30.3	48.3 26.2	51.7 24.1	38.6	37.9 19.3
Elongation, ultimate	23 260	D 1708	%	7.5 7	5.5 5.2	2.5 2	5.5 5.3	3.5	1 0.7
Flexural strength, ultimate	23 260	D790	MPa	82.7 44.8	82.7 48.3	62.1 37.9	68.9 34.5	55.1 31	
Flexural modulus	23 260	D790	MPa	2482 1448	3171 1792	4826 2758	2758 1379	3445 2205	
Compressive strength at 1 % strain at 10 % strain at 0.1 % offset	23	D695	MPa	24.1 112.4 33.1	22.8 104.8 33.8	24.1 93.8 25.5	14.5 75.8 27.6	14.5 78.6	40
Impact strength, Izod, notched Impact strength, Izod, unnotched	23	D256	J/m	42.7 747	42.7 320				
Coefficient of friction PV = 0.875 MPa.m/s PV = 3.5 MPa.m/s Max. PV Wear rate at PV 0.875 MPa.m/s			MPa.m/s m/s 10 <sup>-10</sup>	0.29 17 - 85	0.24 0.12 12 6.3	0.3 0.09 10 4.2	0.12 0.08 3.6 4.9	3.6	0.1 0.05 12
Thermal conductivity	40		W/m.°C	0.29	0.46	0.89	0.42		2.53
Coefficient of linear thermal expansion			µm/m.°C	50	41	27	41	26	13
Water absorption, equilibrium, 50% RH		D570	%	1.0 - 1.3	0.8 - 1.1				
Specific gravity		D792		1.34	1.42	1.56	1.46		1.74
Deformation under load	50	D648	%	0.2	0.17	0.14	0.29	0.3	

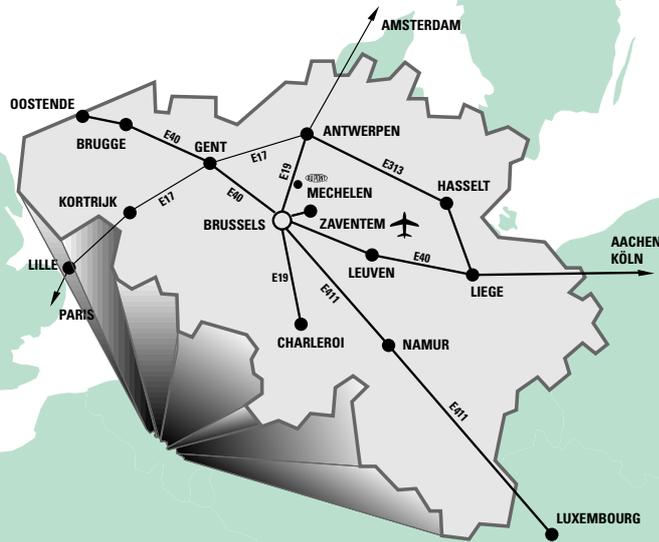
\* Some values for the new compositions SP 221 and SP 262 are preliminary or have been extrapolated from initial test data .  
For more technical details related to the product compositions or to your typical application, refer to the Vespel® Design Handbook and contact your Local Sales Engineer.

# VESPEL®



## Vespel® offer

- Supply of finished parts
- Sites in USA, Japan and Europe
- Centralized services in Mechelen (Belgium)
- Quality ISO 9001
- Door-to-door delivery
- Tool design and parts production
- Machining services available



## Marketing team

- Local qualified field engineers in direct contact with customers
- Quoting in EU-currencies
- Wide knowledge of applications
- Product development support

## Technical team

- Handling your technical enquiries
- Assisting you with your developments
- Design & testing
- CAD, FEA
- New composition developments

Requests for further information from countries not listed should be sent to:

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